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Challenge of ensuring sustainable and clean groundwater

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It is often said that groundwater is like fixed deposit in a bank. It is supposed to earn you handsome interest but is not to be broken to meet your day-to-day expenses. If one is forced to break fixed deposit, it means that financial condition of the person is in a dire state. Groundwater resources for any country act as a buffer in its ecological system. Surplus groundwater is available for use but it should be replenished regularly. Only then will it act as hedge against shortages and calamities. It can lead to a dangerous situation if we withdraw more and replenish less. In many parts of India we have reached this stage with regard to groundwater. The use of groundwater as a primary source of supply is increasing as freshwater availability depletes for various reasons.

About one third of the largest groundwater basins globally are rapidly getting depleted due to over-exploitation. This was revealed in two studies on resilience of major groundwater aquifers conducted by the University of California, Irvine (UCI), using data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites.[1,2] Thirteen of 37 largest aquifers studied between 2003 and 2013 were being depleted while receiving little to no recharge. Eight have been classified as "overstressed," with nearly no natural replenishment to offset usage. Another five were found to be "extremely" or "highly" stressed, depending upon the level of replenishment in each. The Indus Basin aquifer spread underneath northwestern India and Pakistan is the second-most overstressed, while the Murzuk-Djado Basin in northern Africa is third. California's Central Valley, used heavily for agriculture and suffering rapid depletion was also labeled highly stressed. The current drought in California is a testimony to the worsening situation.

Unlike earth observation satellites that indicate presence of groundwater based on remote sensing data, GRACE satellites measure dips and bumps in earth's gravity, which are affected by the mass of water. The groundwater estimates are thus based on measurement of gravity data. The two studies have concluded that there are five aquifers with negative rates of use where the statistics-based withdrawal rate exceeds the GRACE-based estimates. These include the Ganges, the Indus Basin, the Californian Central Valley Aquifer System, the North China Aquifer System and the Tarim Basin. Factors taken into consideration included irrigation demand and population density while making the calculations. Four of these five aquifers have very high levels of irrigation demand and are among the most densely populated regions. The Ganges aquifer has the highest rate of use from both GRACE and statistical data.

Present status of groundwater resources

The quantification of groundwater resources is a complex exercise. A host of agencies, ministries, boards and committees are involved managing water resources in India. The task relating to monitoring groundwater

is handled by the Central Ground Water Board (CGWB) and the network of state groundwater boards. The CGWB assesses groundwater resources of the country periodically, based on two categories - Annually Rechargeable Dynamic Groundwater and Static Groundwater Resource. Rechargeable resource is dynamic and depends on monsoon rainfall and other runoff, while the static groundwater reserves are located below the dynamic resource and are evaluated on the basis of exploratory drilling done by CGWB. Usually the static resource is assessed to the depth of 450 meters in soft rock and 100 meters in hard rock areas. Groundwater levels are measured four times a year during January, April/ May, August and November in the network of over 15500 observation wells located all over the country. The data is analyzed to arrive at frequency distribution of water levels during different periods as well as seasonal, annual and decadal fluctuations. The water level and fluctuation maps are prepared for each monitoring period to study the spatial and temporal changes.

The annual rechargeable groundwater resource for the entire country has been assessed as 431 billion cubic meter (bcm).[3] The major source of groundwater recharge is the monsoon rainfall. About 57% of the annual rechargeable resources - 246 bcm - is contributed by monsoon rainfall recharge. The overall contribution of rainfall to the annual addition of groundwater is 68%, while the rest comes from other sources like canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservations structures. Rechargeable groundwater is significantly high in the Indus-Ganga- Brahmaputra alluvial belt in the North, East and Northeast India covering states of Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and valley areas of Northeastern states where rainfall is plenty and thick piles of unconsolidated alluvial formations are conducive for recharge. Keeping 35 bcm for natural discharge, the net annual groundwater availability for the entire country is 396 bcm, according to CGWB. Out of this, the annual groundwater draft for irrigation alone is estimated to be 245 bcm. The overall estimate of annual replenishable ground water resources of the entire country shows a marginal decrease in the 2014 estimate as compared to 2004 by about 2 bcm but there are significant variations among states.

The stage of groundwater 'development' in the country is 62%, according to the CGWB. By development, the board actually means groundwater exploitation. The status of groundwater exploitation is more than 100 % in Delhi, Haryana, Punjab and Rajasthan. This means that in these states the annual groundwater consumption is more than annual groundwater recharge. In Gujarat, Tamil Nadu and Uttar Pradesh and union territories of Daman and Diu, Lakshadweep and Puducherry, the stage of ground water development is 70% and above. In rest of the states, the stage of groundwater development is below 70%. The groundwater development activities have increased generally in the areas where future scope for groundwater development existed. This has resulted in increase in stage of groundwater 'development' from 58% in 2004 to 62% in 2014.

Out of 5842 administrative units (blocks/taluks/ mandals/districts) assessed all over the country, 802 are 'over-exploited', 169 units are categorised as critical, 523 are semi-critical, while 4277 units are considered safe. In addition, 71 units have been assessed as having completely saline groundwater. The number of over-exploited and critical units is significantly higher in Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Punjab, Rajasthan and Tamil Nadu.

Reasons for groundwater depletion

The groundwater situation in India has not always been so precarious. It is a relatively new development which experts trace to the onset of the Green Revolution on the 1960s.

Enhancing agricultural production through the use of high-yielding varieties required inputs like chemical fertilizers and intensive irrigation. Crops like paddy, which were the mainstay of the green revolution, are water intensive. The availability of irrigation sources

was boosted through investments in irrigation projects but farmers were also encouraged to use groundwater for irrigation. They were given incentives in the form of cheap or free electricity to install agricultural pump sets to irrigate their fields.

The green revolution was accompanied by the 'tubewell or borewell revolution', particularly in states like Punjab and Haryana. Centrifugal pumps which carry water on the surface got progressively replaced with submersible pumps. As water tables kept declining, farmers kept digging deeper and deeper. All this resulted in overall depletion and over-exploitation of groundwater. It is estimated that out of 20 million tubewellls in the country, 1.3 million are in Punjab alone. The problem is severe in central Punjab area where rice is grown extensively. While the average annual fall in groundwater table in the central Punjab was about 17 cm during the 1980s and about 25 cm during the 1990s, it was alarmingly high at 91 cm per annum during 2000– 2005, according to data compiled scientists from by the Punjab Agriculture University.[4] Out of 142 blocks in the state, water table is declining in 110 blocks due to over-extraction of groundwater. By 2023, the water table depth in central Punjab is projected to fall below 70 feet in 66% area, below 100 feet in 34% area and below 130 feet in 7% area, studies have projected. Groundwater depletion can have direct impact on productivity since most farmers depend on it for irrigating their crops. About 10% of the farmers in the study reported a decline in the area under paddy due to groundwater decline.

Similar evidence is emerging from another 'green revolution' state, Haryana. A study done in Karnal showed that groundwater is a vital source of irrigation as most of net irrigated area is covered by tube well irrigation, with groundwater contributing up to 70% of total water needed for agriculture.[5] Wheat and rice the main crops grown in this belt. Water is extracted through large number of shallow tube wells and dug-cum-bore holes. Researchers have noted indiscriminate use of groundwater for irrigating rice crop coupled with decreasing trends in rainfall during transplanting season of rice has resulted in depletion of groundwater at an alarming rate. If we include Punjab, Haryana, western Uttar Pradesh and parts of Rajasthan where irrigation-intensive rice, sugarcane and wheat are grown, we can see the stress on groundwater in this region. Quoting official data, environment scientist Vikram Soni has concluded that water intensive rice and sugarcane growing areas in this region amount to about 100,000 sq. km, and about 60% of the cultivated area is serviced entirely by groundwater.[6]

In urban areas, the main reason for decline in groundwater is urbanization itself. The urban population in India has grown three-folds since the independence. The number of people living in cities is growing constantly – rising from 25.7% in 1991 to 31.16 percent in 2011 census. The urban population growth rate is significantly higher than the overall population growth rate. People move to cities for economic opportunities and jobs with economic growth. The falling interest in farming is another reason for people to move to cities to work in services and industrial sectors. While urban populations are growing, cities and towns have not kept pace with urban infrastructure like roads, housing, sanitation and water supply. Urban growth is haphazard, creating stress of water resources. Existing water sources for cities like rivers, lakes and ponds are not sufficient to meet growing demand. Half a century ago, most of the rivers in India were biologically in good condition, amply met the water needs of the populations and also supported diverse fish and flora species.[7] Today, it would be difficult to find a single river in the plains of the country that would have potable water.

In cities, water has to be transported over long distances to meet the demand, and still many people have no access to it as they live in slums or areas not covered by piped water supplies. In such a situation, groundwater becomes primary source of supply for people. Since urban growth is unplanned, existing water harvesting and storage structures have either become dysfunctional or have been broken, natural water supply channels and drainage systems are obstructed. The result is overdraw of water resulting in a fall in water tables in cities. The groundwater resources of 20 tehsils of National Capital Territory of Delhi are overexploited with stage of development reaching to even 243% in the south district.[8] Another main reason for decline in groundwater is rapid growth in industrial activity. In the absence of regular water supplies, industrial units mostly depend on groundwater. Since there is no regulation, they tend to overdraw and replenish less. It has been pointed out by experts that mining activity

could also destroy groundwater recharge systems in mined areas. Many mining companies, pump out groundwater to make mining possible. Deforestation, destruction of traditional water systems like ponds, tanks, lakes and wetlands, interruption in flow of rivers are also adversely affecting groundwater recharge.

Contamination and pollution

The quality of groundwater is also a major problem. In industrial areas and cities with insufficient drainage systems, contamination of groundwater is a major problem. Improper disposal of industrial effluents and sewage is directly affecting quality of groundwater in many parts of the country. Some unscrupulous industries directly inject untreated toxic waste into the ground. There are several industrial waste and toxic hotspots in the country where groundwater has been found to be highly polluted.

For instance, the closed Union Carbide plant in Bhopal has become a source of groundwater pollution as chemicals stored in the factory have been leaching into the for the past three decades. Pollution caused by hexavalent chromium in Kanpur due to tanneries has been a cause of concern in Kanpur for decades. Tanneries in Tamil Nadu have also been responsible for groundwater pollution. Shallow aquifers are the worst affected due to pollution. Nitrate pollution of groundwater is quite rampant in many Indian cities due to improper waste management practices. Sanganer in Rajasthan is famous for printed fabric, but extensive use of chemical dyes –instead of vegetable dyes used in the past – is causing groundwater pollution in the region. Large quantities of toxic waste are dumped into canals, open ponds and nallahs, with much of it percolating to reach groundwater reserves.

In addition to man-made pollution, groundwater also gets contaminated due to natural factors abetted by overexploitation of groundwater. The problem of fluoride and arsenic fall in this category. Studies done by CGWB have shown that groundwater in parts of 20 states is contaminated by fluoride and in 21 states by nitrate in excess of World Health Organization (WHO) standards.[9] As per these standards for drinking water, fluoride should not be more than 1.5 mg/l and nitrate should not be more than 50 mg/l.

In addition, groundwater in 10 states has been found to have excess concentration of arsenic, water in 24 states has higher concentration of iron and concentration of heavy metals like lead, chromium and cadmium in higher in 15 states. The fluoride minerals present in soil contribute to fluoride pollution. High fluoride levels are mostly found in the areas where groundwater is brackish to saline in nature. Human activities like use of fluoride salts in steel, aluminum, bricks and tile-industries and also agricultural discharges, are also contributing for fluoride pollution in groundwater.

The presence of arsenic in groundwater is another major problem In India. It was first discovered in West Bengal in 1983 and since them it has been widely reported from Jharkhand, Bihar, Uttar Pradesh, Assam and Manipur. Lakhs of people have been chronically exposed to drinking arsenic-laden water from tube wells and have been reporting a range of health problems. Millions more affected indirectly as they consume food, mainly rice, grown in arsenic-affected areas where groundwater used for all farming operations. It is feared that food is the second largest contributor to arsenic intake by people after direct ingestion of arsenic contaminated water. The actual source of groundwater arsenic contamination, in the Ganga–Brahmaputra basin, is yet to be established. The sources of arsenic are natural or may partly stem from anthropogenic activities like intense exploitation of groundwater, application of fertilizers, burning of coal and leaching of metals from coal-ash tailings.[10]

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Rainwater harvesting, recharge and regulation

If the problem of groundwater over-exploitation and pollution is serious, the solutions are simple. To begin with there has to be regulation of groundwater to stop over-withdrawal and misuse. The Central Ground Water Authority has begun regulating withdrawal of ground water by industries in 802 "over-exploited" and 169 "critical assessment units" all over the country.

In addition, authority has notified 162 critical and overexploited areas in parts of NCT Delhi, Haryana, Punjab, Andhra Pradesh, Rajasthan, MP, Gujarat, West Bengal, Uttar Pradesh, Karnataka, Tamil Nadu, UT of Puducherry and Diu for control and regulation of groundwater. Deputy Commissioners and District Magistrates in these areas have been directed to take action under Section 5 of Environment (Protection) Act, 1986 to regulate groundwater. Construction of new groundwater structures has been prohibited in these notified areas, and permission to drill tubewells is being granted only to government agencies engaged in drinking water supply. All these measures are much needed and should be implemented strictly.

The CGWB has also suggested to states to enact groundwater legislation based on a model framework circulated to them. Till now Andhra Pradesh, Goa, Tamil Nadu, Kerala, West Bengal, Himachal Pradesh and union territories of Lakshadweep and Pondicherry have enacted and implemented ground water legislation.

Under the model Bill, each state will have a groundwater authority with powers to regulate and control development and management of groundwater. There are provisions for registration of users in both notified and non-notified areas. In addition, the law provides for promoting rainwater harvesting to improve groundwater situation. A state authority may identify recharge worthy areas in and issue necessary guidelines for adoption of rainwater harvesting. In rural areas, watershed management to facilitate groundwater recharge may be encouraged through community participation. Rainwater harvesting may be made a necessary component of all development schemes. In urban areas with precarious groundwater situation, the authority may issue directives for construction of appropriate rainwater harvesting structures in residential, commercial and other premises.

The CGWB has also prepared a conceptual document entitled "Master Plan for Artificial Recharge to Ground Water in India" envisaging construction of 1.11 crore rainwater harvesting and artificial recharge structures in the country.[11] The estimated cost of this will be Rs 79,178 crores and these structures will be able to harness 85 billion cubic metre of water in an area of 941,541 square km by harnessing surplus monsoon runoff to augment ground water resources. The plan has already beenRai circulated to all state governments for implementation. During the eleventh plan, 133 demonstration recharge projects costing Rs. 99.87 crore were approved for construction of artificial recharge structures in 22 states.

Groundwater is a finite resource. All steps must be taken to use it judiciously. We need continuous research and development to map this resource fully and monitor it on a regular basis. In arsenic and fluoride affected areas, alternative arrangements for safe drinking supplies should be made. Overexploitation must be prevented and stopped through regulation as well as education and awareness creation. At the same time, natural rainwater harvesting structures must be restored and artificial structures should be built in both urban and rural areas. Rainwater harvesting and water conservation should become participatory processes and people's movement.

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